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Effect of Proposed North-South Expressway on Peak Flood Flows and Levels in Lower Red Hill Creek.

Nov. 1983

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EFFECT OF PROPOSED NORTH - SOUTH EXPRESSWAY ON PEAK FLOOD FLOWS AND LEVELS IN LOWER RED HILL CREEK

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Paragon Engineering Limited

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November 21, 1983

Mr. S. A. Stinson, P.Eng.
Delcan Limited
375 Wellington Road
London, Ontario
N6C 4P9

Dear Sir

Analysis to Determine Impact of Proposed North-South Expressway on Flood Flows and Levels in Lower Red Hill Creek

We are pleased to submit with this letter our report describing the work carried out, and presenting the results and conclusions arrived at, during this analysis. This is a revision of our earlier report dated November 3, 1983 and incorporates corrections made to the hydraulic model of the area for existing and proposed conditions.

In this report, only results at key locations are presented but flood level and velocity results for all conditions investigated are available for all sections in the study area.

The results of the analysis indicate that the expressway will have an impact on peak flows in the study area, with post-construction peaks for several storms being approximately 30% to 50% higher than at present. However these increases in peak flows are due to decreases in flood levels upstream of existing embankments.

Should you have any questions regarding this report or analysis, please contact us at your convenience.

Yours very truly

PARAGON ENGINEERING LIMITED

Larry Thompson

Larry Thompson, M.A.Sc., P.Eng.

LT/br

EFFECT OF PROPOSED NORTH - SOUTH EXPRESSWAY ON PEAK FLOOD FLOWS AND LEVELS IN LOWER RED HILL CREEK

November 1983

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1.0 INTRODUCTION

In order to improve the transportation network around the City of Hamilton it has been proposed to construct a "Mountain East-West and North-South" transportation corridor (expressway) which would link the Q.E.W. Highway near the east end of Hamilton to Highway 403 near Ancaster.

Almost the entire length of this corridor would be within a watershed known as Red Hill Creek and it has been proposed to construct the north-south portion along the lower creek valley. The location of the proposed corridor is shown on a series of plans in Appendix 'A' of this report and a map of the Red Hill Creek watershed is included as Map 1.

The Red Hill Creek watershed is comprised of two distinct portions:

1) The upper watershed comprising roughly 75% of the drainage area and lying above the Niagara Escarpment (Hamilton Mountain Area).

2) The lower watershed which is comprised of a deep wide valley with narrow strips of local contributing drainage area. This valley is crossed by several high embankments which, during periods of high flow, back water up in the valley and act as natural flood control reservoirs.

An environmental assessment report on the proposed corridor was prepared by Delcan Limited and submitted to various governmental agencies for review in 1982.

A comprehensive stormwater management study of the Red Hill Creek watershed was carried out during 1981 and 1982 by Mr. Larry Thompson when he was at Philips Planning and Engineering Limited. This study utilized the SUBHYD-ROUTE hydrologic modelling

package developed by Mr. Thompson and took into account the effect of flood storage behind various embankments in the lower watershed on peak flows and levels. Previous studies of the watershed had not considered these storage effects.

Following review of the environmental assessment study for the corridor and after considering the results of the stormwater management analysis of the watershed, questions were raised by government reviewers concerning the impact that the north-south portion of the corridor would have on peak flows and levels in the lower Red Hill Creek watershed. These concerns were based on the following factors:

1) Construction of the expressway would involve the placing of considerable fill in the valley thereby eliminating some flood storage.

2) The proposed expressway would also pass through certain of the existing embankments thereby effectively increasing the hydraulic capacity of these crossings and thus decreasing upstream flood levels and storage utilization.

3) The valley flood storage along the study area had been shown to be quite effective in reducing peak flood flows and thus any reduction in effective storage would be expected to lead to higher peak flows in the lower Red Hill Creek watershed.

In order to determine the impact that the proposed expressway would have on peak flows and levels in the lower Red Hill Creek watershed, Delcan Limited asked Mr. Larry Thompson, now of Paragon Engineering Limited to carry out an analysis of the pre and post construction situation for various design storm conditions.

2.0 METHOD OF ANALYSIS

2.1 DESCRIPTION

The analysis involved work carried out by both Delcan Limited and Paragon Engineering Limited and proceeded as follows:

1. Delcan prepared a hydraulic computer model of the lower watershed (Windermere Basin to just upstream of the T H & B embankment) using the U.S. Army Corps of Engineers HEC-2 program. This model was based on data from various sources including earlier work done by M. M. Dillon Limited, new topographic mapping of the watershed, and limited field survey and verification.

   Two versions of this model were prepared to correspond to pre and post development conditions and this model for existing conditions represents an improvement over the earlier Dillon model used in the Philips Stormwater Management Study. The most significant corrections were made in the modelling of the TH+B, CNR and Barton St. structures.

2. All necessary data used in the Philips Stormwater Management Study were obtained from the City of Hamilton Engineering Department.

3. The SUBHYD-ROUTE data sets obtained from the City of Hamilton were updated and additional detail added. This was necessary since the earlier study had concentrated on that portion of the watershed upstream of the escarpment. Several subcatchments and routing reaches as noted on Map 1 were further sub-divided in order to improve both the accuracy and density of results along the lower watershed.

4. Multiple profile HEC-2 runs were carried out by Paragon Engineering Limited using the data prepared by Delcan to

determine the pre and post construction discharge-storage relations for the lower watershed (15 flows were considered).

5. These discharge-storage relations (rating curves) were input to the SUBHYD-ROUTE data base and new hydrologic computer runs carried out to determine pre and post construction peak flows resulting from the following design storms:

   2 Year
   5 Year
   10 Year
   25 Year
   100 Year
   Regional

   All computer runs were based on existing land use conditions since it was desired to isolate the impact of the proposed transportation corridor on peak flows and levels.

6. The flows resulting from this hydrologic analysis were then input into the HEC-2 data sets and final pre and post construction flood levels determined for all storms considered.

2.2 PRE AND POST CONSTRUCTION DISCHARGE-STORAGE RELATIONS

In order to graphically depict the impact of the proposed expressway on the flood storage characteristics of the lower watershed, a series of plots were produced for each reach affected. These plots follow as Figures 1 to 6.

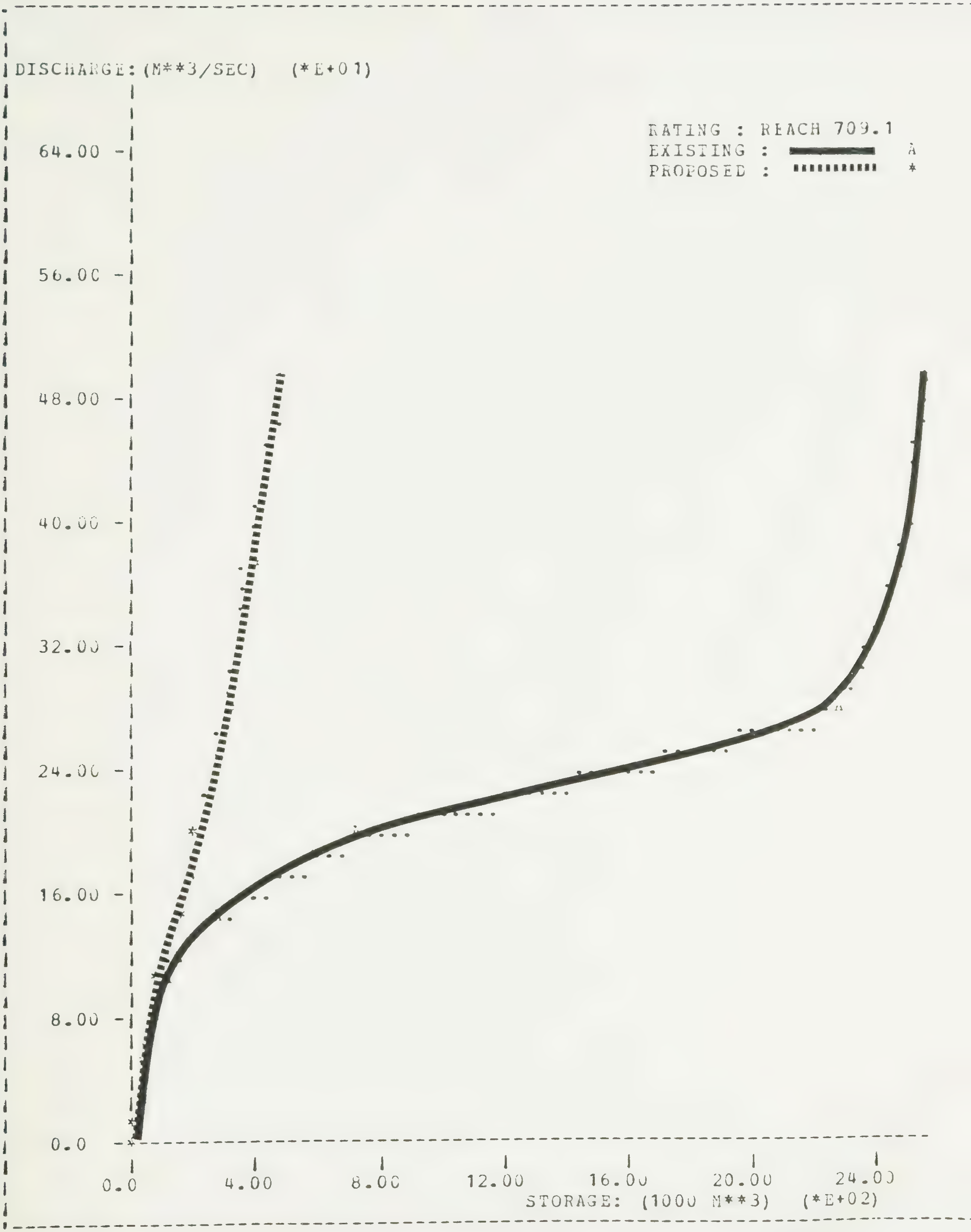
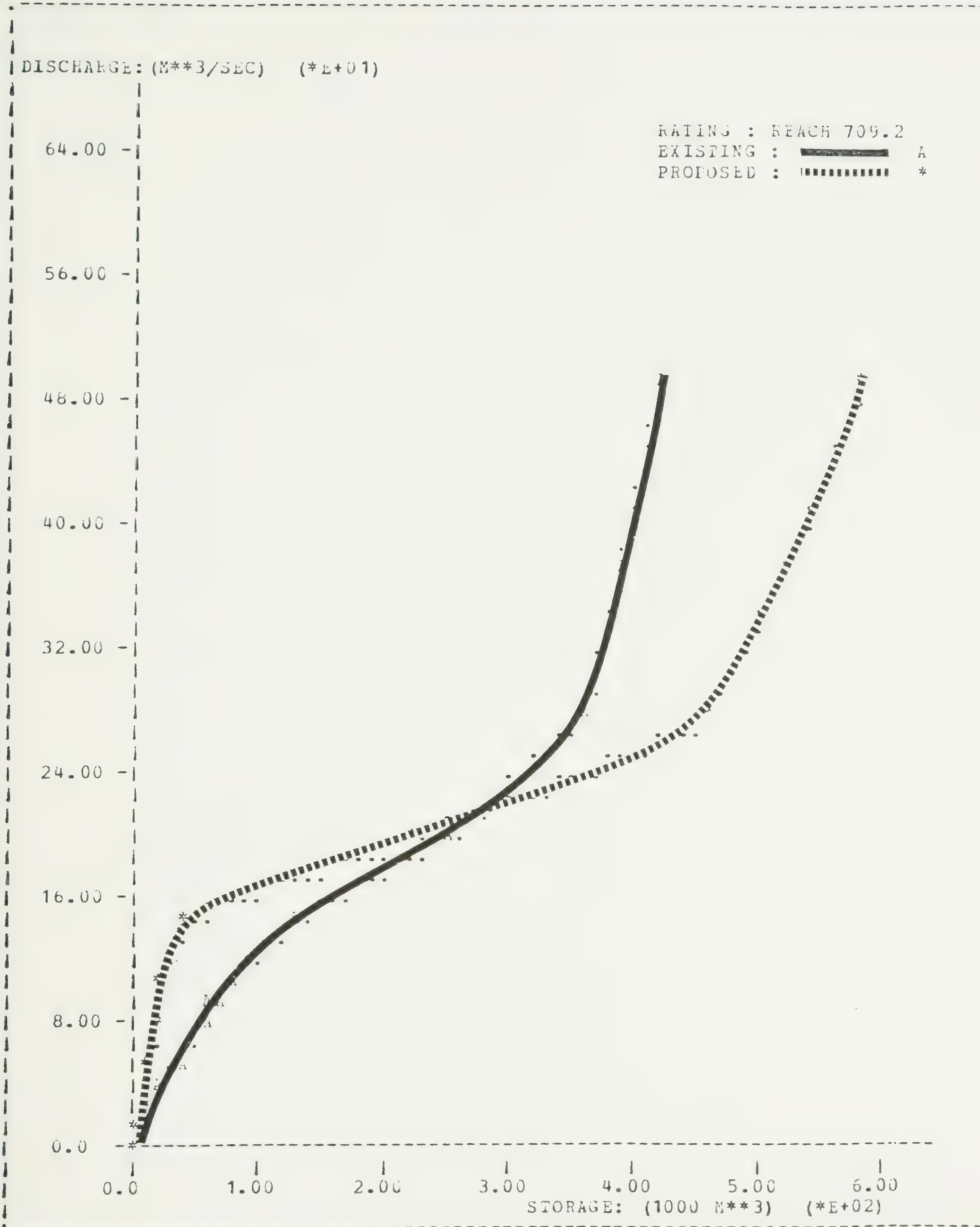

DISCHARGE: (M**3/SEC) (*E+01)
RATING : REACH 709.1
EXISTING : A
PROPOSED : *
64.00
56.00
48.00
40.00
32.00
24.00
16.00
8.00
0.0
0.0
4.00
8.00
12.00
16.00
20.00
24.00
STORAGE: (1000 M**3) (*E+02)

FIGURE NO. 1


DISCHARGE: (M**3/SEC) (*E+01)
RATING : REACH 709.2
EXISTING : A
PROPOSED : *
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56.00
48.00
40.00
32.00
24.00
16.00
8.00
0.0
0.0
1.00
2.00
3.00
4.00
5.00
6.00
STORAGE: (1000 M**3) (*E+02)

FIGURE NO. 2

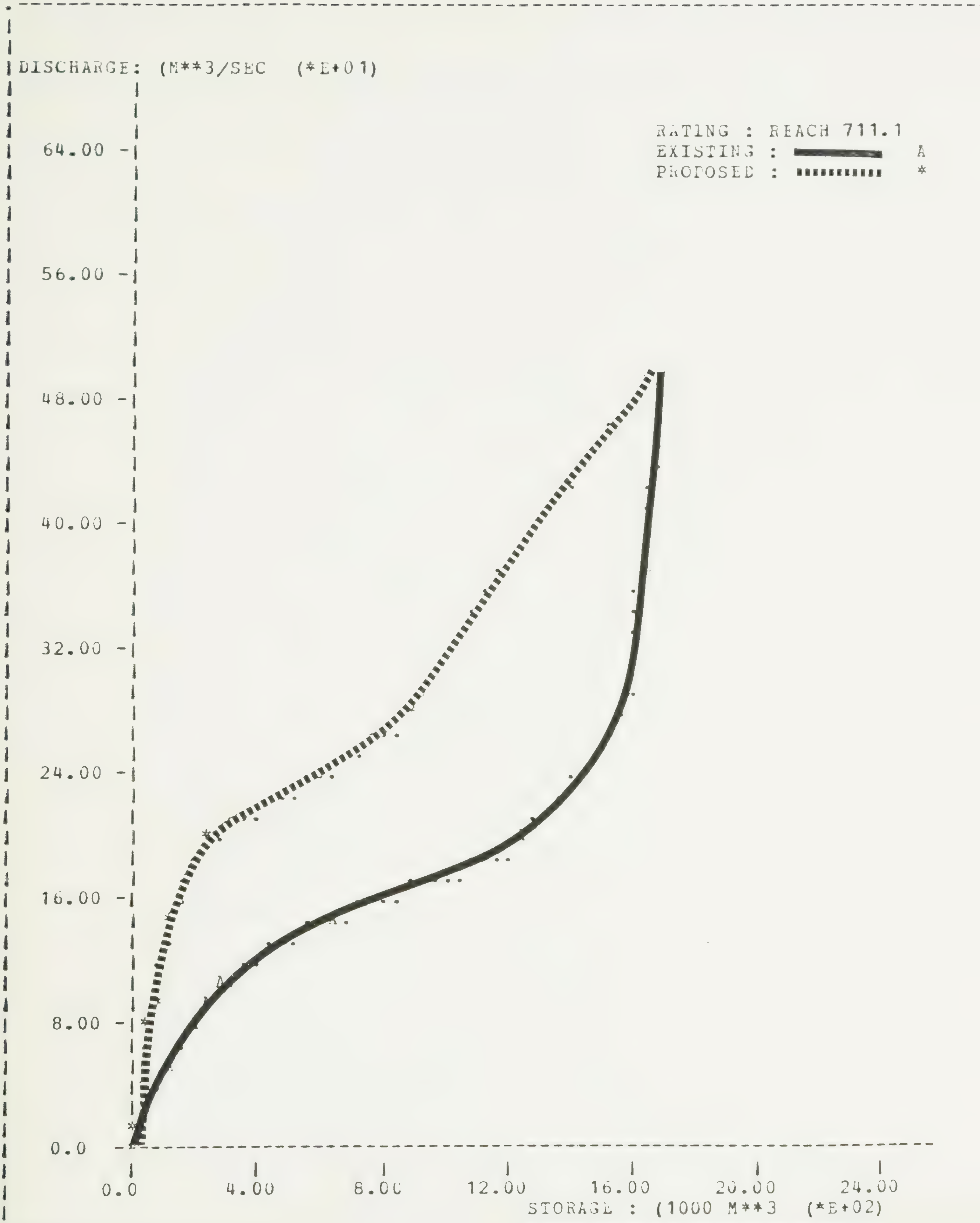

DISCHARGE: (M**3/SEC (*E+01)
RATING : REACH 711.1
EXISTING : A
PROPOSED : *
64.00
56.00
48.00
40.00
32.00
24.00
16.00
8.00
0.0
0.0
4.00
8.00
12.00
16.00
20.00
24.00
STORAGE : (1000 M**3 (*E+02)

FIGURE NO. 3

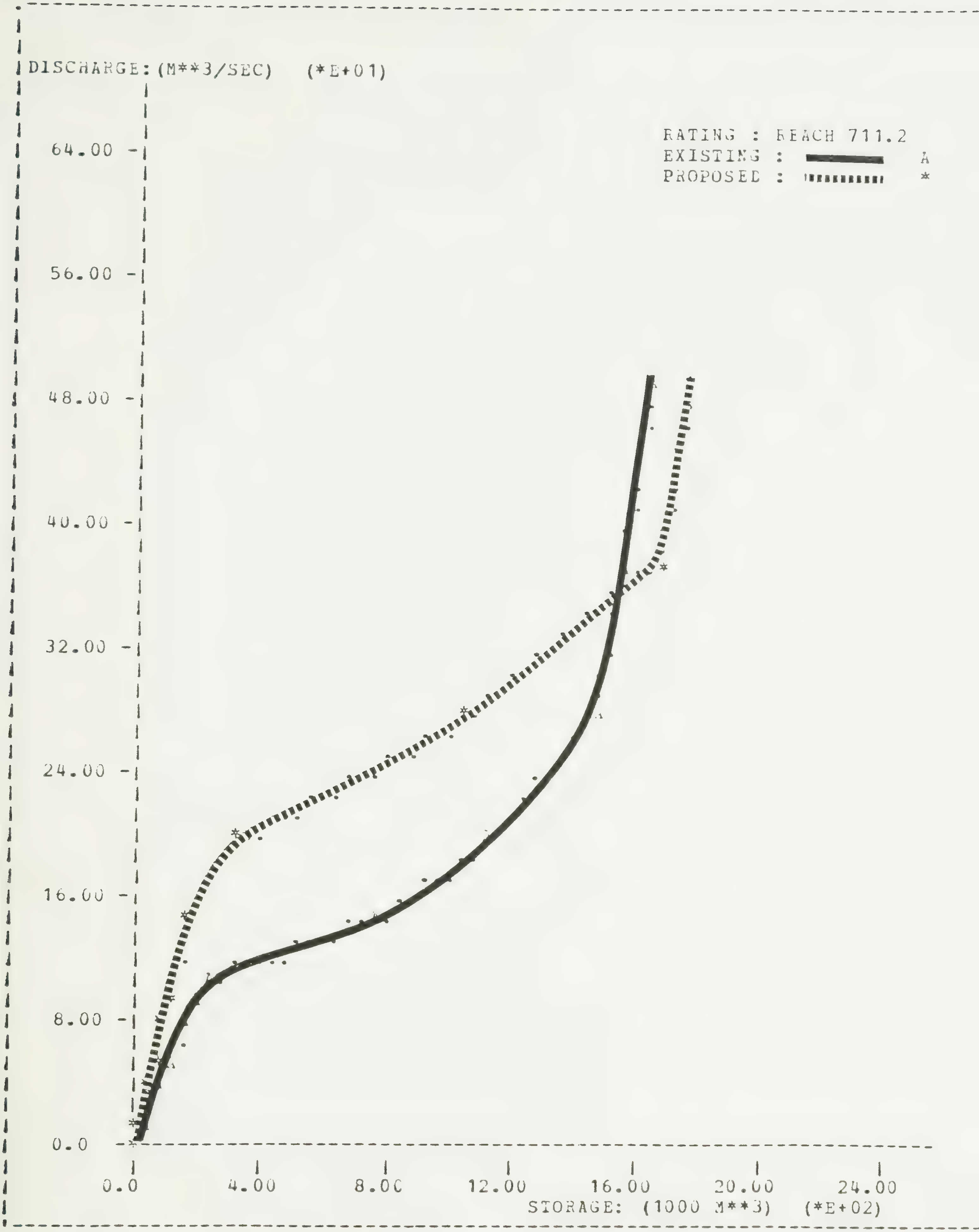

DISCHARGE: (M**3/SEC) (*E+01)
64.00
56.00
48.00
40.00
32.00
24.00
16.00
8.00
0.0
0.0
4.00
8.00
12.00
16.00
20.00
24.00
STORAGE: (1000 M**3) (*E+02)
RATING : REACH 711.2
EXISTING : A
PROPOSED : *

FIGURE NO. 4

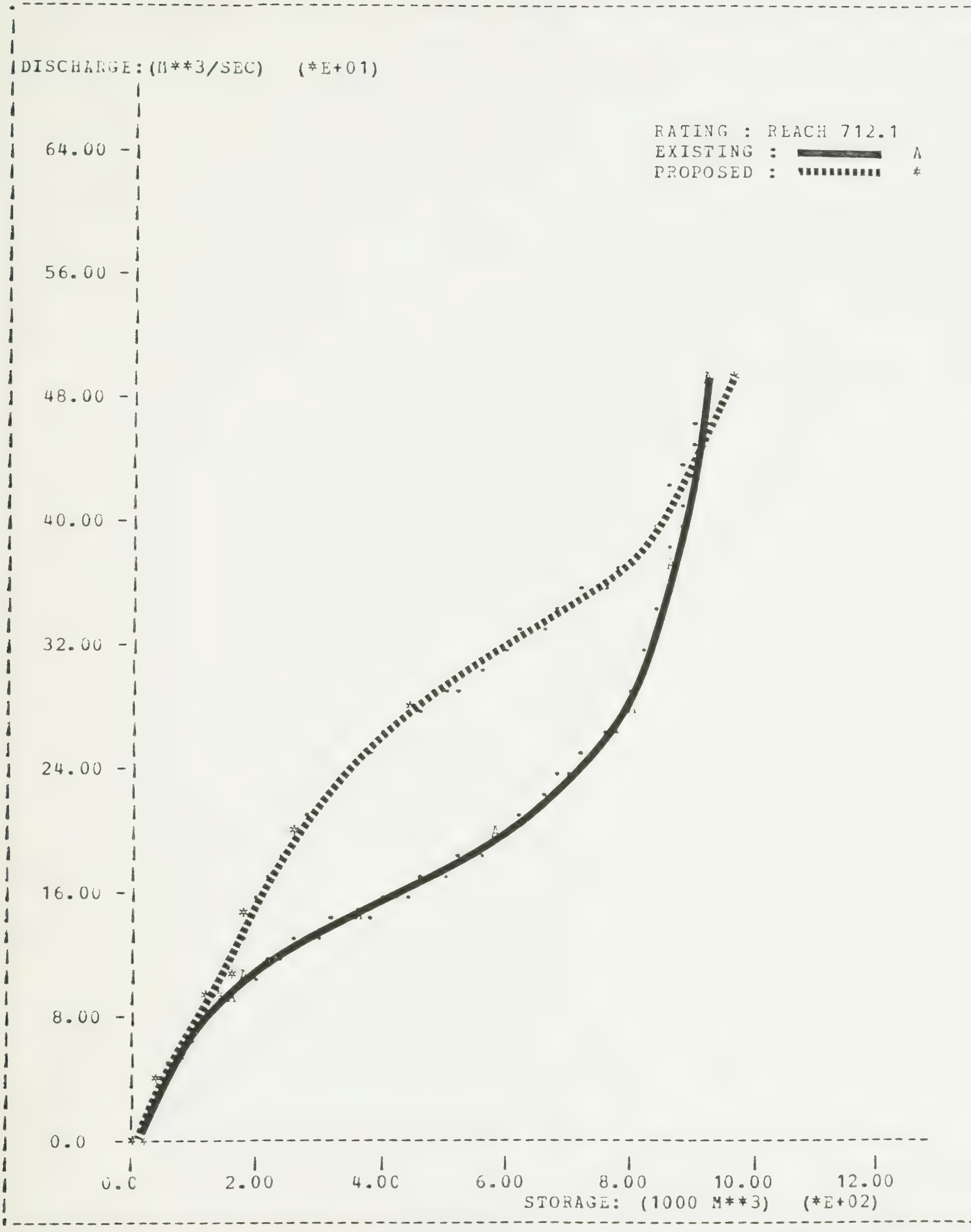

DISCHARGE: (M**3/SEC) (*E+01)
64.00
56.00
48.00
40.00
32.00
24.00
16.00
8.00
0.0
0.0
2.00
4.00
6.00
8.00
10.00
12.00
STORAGE: (1000 M**3) (*E+02)
RATING : REACH 712.1
EXISTING : A
PROPOSED : *

FIGURE NO. 5

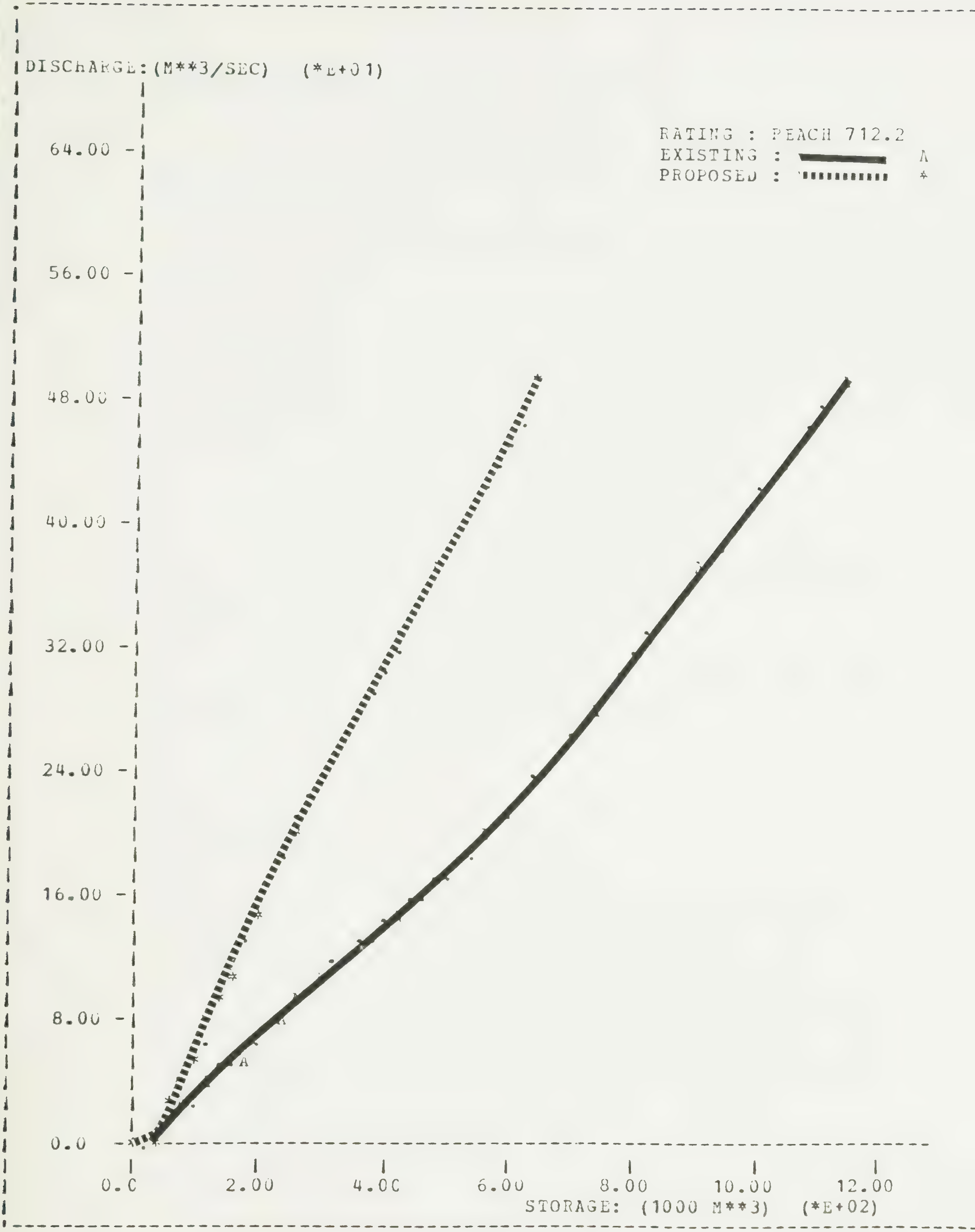

DISCHARGE:(M**3/SEC) (*E+01)
64.00
56.00
48.00
40.00
32.00
24.00
16.00
8.00
0.0
RATING : PEACH 712.2
EXISTING : A
PROPOSED : *
A
0.0
2.00
4.00
6.00
8.00
10.00
12.00
STORAGE: (1000 M**3) (*E+02)

FIGURE NO. 6

3.0 EFFECT OF PROPOSED EXPRESSWAY ON PEAK FLOWS

The results of the analysis regarding pre and post construction peak flows for existing land use conditions are presented in two tables.

Table 1 lists by major crossing location the following:

- node number used in computer program and depicted on Map 1
- return period design storm
- pre construction peak flow
- post construction peak flow
- percent increase in peak flow following construction

Table 2 presents the effectiveness of each of the routing reaches in peak flow reduction for the various design storms and for pre and post construction conditions.

The impact of the expressway on peak flows along the study area is presented on a reach basis.

3.1 REACH 709.1

This reach is controlled by the approximately 16 m high T H & B embankment and is very effective in controlling peak flows. Construction of the expressway will create an additional opening in this embankment (roadway will pass beneath the railroad tracks). Since this new opening will be approximately 4 m above the valley bottom, there will be very little impact on the crossing's hydraulic characteristics for low flows but a marked increase in capacity for higher flows.

TABLE 1

EFFECT OF PROPOSED EXPRESSWAY ON PEAK FLOWS

ALONG LOWER REDHILL CREEK

LOCATION	NODE NUMBER	RETURN PERIOD DESIGN STORM	PEAK FLOW (M^3/SEC) EXISTING	PEAK FLOW (M^3/SEC) PROPOSED (WITH EXPRESSWAY)	% INCREASE IN PEAK FLOW
T.H. & B. Railway	20.1	2	28	28	0
		5	86	85	1.2
		10	122	135	10.7
		25	138	162	17.4
		100	180	264	46.7
		Regional	248	434	75.0
King St.	22	2	33	35	6.1
		5	96	100	4.2
		10	143	154	7.8
		25	161	180	11.8
		100	212	249	17.5
		Regional	331	504	52.3
Queenston Road	22.1	2	27	31	14.8
		5	72	96	33.3
		10	112	148	32.1
		25	122	168	37.7
		100	161	215	33.5
		Regional	314	384	22.2
Barton Street	23	2	22	27	22.7
		5	63	87	38.1
		10	104	143	37.5
		25	111	159	43.2
		100	131	203	55.0
		Regional	271	306	12.9
Brampton Street	23.1	2	21	25	19.0
		5	59	77	30.5
		10	98	138	40.8
		25	106	155	46.2
		100	127	201	58.3
		Regional	262	295	12.6
Woodward Avenue (Mouth of Creek)	24	2	13	21	16.7
		5	53	74	39.6
		10	91	131	44.0
		25	100	151	51.0
		100	125	200	60.0
		Regional	256	293	14.5

TABLE 2

EFFECTIVENESS OF VALLEY STORAGE IN PEAK FLOW REDUCTION ALONG THE LOWER REDHILL CREEK WITH AND WITHOUT THE PROPOSED EXPRESSWAY

REACH NO.	RETURN PERIOD DESIGN STORM	EXISTING			PROPOSED (WITH EXPRESSWAY)		
		PEAK INFLOW (cms)	PEAK OUTFLOW (cms)	PEAK FLOW REDUCTION (%)	PEAK INFLOW (cms)	PEAK OUTFLOW (cms)	PEAK FLOW REDUCTION (%)
709.1	2	37.1	28.0	24.5	37.1	28.4	23.5
	5	122.7	85.5	30.3	122.7	85.4	30.4
	10	169.7	121.7	28.3	169.7	134.5	20.7
	25	206.3	137.9	33.2	206.3	161.6	21.7
	100	318.1	179.5	43.6	318.1	263.8	17.1
	Regional	440.9	247.7	43.8	440.9	433.8	1.6
709.2	2	28.0	26.4	5.7	28.4	27.9	1.8
	5	85.5	79.4	7.1	85.4	85.1	0.4
	10	121.7	117.1	3.8	134.5	132.9	1.2
	25	137.9	131.5	4.6	161.6	152.8	5.4
	100	179.5	171.2	4.6	263.8	212.7	19.4
	Regional	247.7	245.1	1.0	433.8	429.3	1.0
711.1	2	32.9	26.7	18.8	34.6	31.0	10.4
	5	95.7	71.4	25.4	100.2	95.2	5.0
	10	143.1	111.7	21.9	153.5	147.1	4.2
	25	160.6	121.3	24.5	179.7	166.7	7.2
	100	212.0	160.1	24.5	249.4	214.4	14.0
	Regional	330.6	314.1	5.0	504.4	379.8	24.7
711.2	2	26.9	22.3	17.1	31.2	27.0	13.5
	5	71.8	62.7	12.7	96.1	86.3	10.2
	10	112.3	103.7	7.7	148.0	142.1	4.0
	25	121.6	110.7	9.0	167.5	157.7	5.9
	100	160.6	131.1	18.4	215.1	202.7	5.8
	Regional	314.1	270.8	13.8	384.4	305.8	20.4

Continued .....

TABLE 2 (Continued)

		EXISTING			PROPOSED (WITH EXPRESSWAY)		
REACH NO.	RETURN PERIOD DESIGN STORM	PEAK INFLOW (cms)	PEAK OUTFLOW (cms)	PEAK FLOW REDUCTION (%)	PEAK INFLOW (cms)	PEAK OUTFLOW (cms)	PEAK FLOW REDUCTION (%)
712.1	2	22.4	21.3	4.9	27.1	24.6	9.2
	5	62.8	59.3	5.6	87.0	77.3	11.1
	10	104.1	97.8	6.1	143.0	137.8	3.6
	25	110.8	106.2	4.2	158.5	154.7	2.4
	100	131.1	126.9	3.2	203.4	201.0	1.2
	Regional	270.8	261.6	3.4	305.8	294.8	3.6
712.2	2	21.4	17.6	17.8	24.7	20.9	15.4
	5	59.3	52.9	10.8	77.5	73.9	4.6
	10	97.9	90.9	7.2	138.3	130.9	5.4
	25	106.2	100.3	5.6	155.1	151.1	2.6
	100	126.9	124.5	1.9	201.4	199.5	0.9
	Regional	261.6	256.0	2.1	294.8	293.0	0.6

Examination of Tables 1 and 2 indicates the following:

- the 2 and 5 year storm flows are not significantly affected and peak flow reductions of 24 to 30% occur.
- there will be a significant increase in peak flows from the 25 to 100 year storms ranging from 11 to 47% respectively. Peak flow attenuation will still occur but in the future will be in the 21 to 17% range rather than the 28 to 44% range found at present.
- with the present conditions Regional storm peak flows would be reduced by 44% (however the embankment would possibly be unstable in this condition, although it would not be overtopped). With the construction of the expressway , Regional flood levels upstream of the TH+B embankment will be greatly reduced with the result that virtually no attenuation of the Regional storm peak flow will occur.

3.2 REACH 709.2

This is a short reach running from King Street to the TH+B. At the present time storage in this reach has only a minor impact on peak flows. Although post-construction peak flow attenuation for the 2 to 10 year storms will be reduced the utilization and availability of storage during the 25 to 100 year storms will be increased. Under 100 year storm post construction conditions significant peak flow reduction in the 19% range would occur.

Increases in peak flows at this location are primarily due to changes in Reach 709.1 (TH+B embankment).

3.3 REACH 711.1

This reach runs from Queenston Road to King Street and at the present time, peak flows from the 2 to 100 year storms are reduced by approximately 23%. The effectiveness of this reach in controlling peak flows will be significantly reduced for these storms with post construction peak flow reduction in the 4% to 14% range.

Regional storm peak flow attenuation will be significantly increased however, from 5 to 25%.

This factor, coupled with changes upstream, will lead to post construction peak flows at Queenston Road changing as follows:

- increase of 15% for the 2 year storm.
- increase of approximately 34% for the 5 to 100 year storms.
- increase in Regional storm peak flows caused by changes at the TH+B embankment will be partially offset with the result that the Regional storm peak flow will only increase by 22% in this reach.

3.4 REACH 711.2

This reach runs from Barton Street to Queenston Road and has a moderate effect on peak flows. With the expressway peak flow reduction from the 2 to 100 year storms will be reduced from an average of 13% to an average of 8%. Peak flow reduction for the Regional storm will increase from 14 to 20% however, further helping to offset the large increase in Regional storm flow caused by changes at the TH+B embankment

Net peak flows at Barton Street will change as follows:

- 23% increase in 2 year storm peak flow.
- increases in 5 to 100 year storm peak flows in the 43% range
- a moderate increase in Regional storm peak flows of 13%

3.5 REACH 712.1

This reach runs from Brampton Street to Barton Street. At the present time there is no crossing at Brampton Street but one will be constructed along with the expressway. The analysis indicates that under existing conditions, there is very little peak flow reduction here (average of 4.5%) but that moderate peak reduction in the range of 10.5% will occur after construction of the expressway for the 2 and 5 year storms.

The effectiveness of storage on Regional Storm peak flow will be essentially unchanged (change from 3.4 to 3.6%).

Net peak flows in the Brampton Street area will thus change as follows:

- 19% increase in 2 year storm peak flow.
- increases in 5 to 100 year storm flows of 31 to 58%.
- Regional storm peak flow will be 12.6% more than at present.

3.6 REACH 712.2

This reach extends from the mouth of the creek at Windermere Basin upstream to the Brampton Street area.

At the present time, storage in this reach reduces the 2 year storm peak flow by 17.8%. Under post construction conditions, this will be lowered slightly to 15.4%.

Peak flow reductions for the remaining larger storms average 5.5% and will be reduced by the expressway construction to an average of 2.8%.

The net changes in peak flows at the mouth of the creek will be as follows:

- an increase of 17% for the 2 year storm.
- increases of approximately 40 to 60% for the 5 to 100 year storms.
- a moderate increase in Regional storm peak flow of 14.5%

4.0 EFFECT OF PROPOSED EXPRESSWAY ON PEAK FLOOD LEVELS

The flood levels just upstream of the major crossings in the study area are listed in Table 3 for each storm and condition analysed.

Examination of this table reveals the following:

- flood levels just upstream of the TH+B embankment will remain essentially unchanged for the 2 to 25 Year Storms and will be significantly reduced for the 100 Year and Regional storms. Decreases of 1.4 m for the 100 Year storm and 5.2 m for the Regional Storm will occur due to overflow through the extra opening which will be created in the embankment to accommodate the expressway.

- flood levels at King Street will be significantly lower for most storms (2 to 25 year). This would be due to greatly increased culvert capacity. The 100 Year and Regional storm levels will be considerably higher than at present due to both increased peak flows and the top of the embankment being higher.

- flood levels at Queenston Road (Reach 711.1) are significantly reduced for all storms considered (2.4 to 4.4 m reduction). This is due to greatly increased hydraulic capacity. These lower levels are gained at the expense of peak flow reduction since with lower levels, less flood storage is available (see Figure 3).

- flood levels at Barton Street will be increased by 0.8 metres for the 2 and 5 Year storms due primarily to higher post construction flows. Flood levels for the remaining storms will not change significantly.

TABLE 3

FLOOD ELEVATION COMPARISONS

LOCATION	RETURN PERIOD DESIGN STORM	WATER LEVELS (MASL) PRE CONSTRUCTION	WATER LEVELS (MASL) POST CONSTRUCTION	INCREASE IN LEVELS (m)
T.H. & B Railway	2	91.17	90.89	-0.28
	5	92.73	92.55	-0.18
	10	94.34	94.28	-0.06
	25	95.18	95.36	+0.18
	100	97.69	96.32	-1.37
	Regional	102.90	97.73	-5.17
King Street	2	88.67	86.49	-2.18
	5	90.38	87.52	-2.86
	10	91.40	89.25	-2.15
	25	91.78	90.59	-1.19
	100	92.16	94.46	+2.30
	Regional	92.92	97.23	+4.31
Queenston Road	2	84.23	81.79	-2.44
	5	85.67	82.99	-2.68
	10	86.88	83.83	-3.05
	25	87.28	84.13	-3.15
	100	89.19	84.82	-4.37
	Regional	92.77	90.25	-2.52
Barton Street	2	77.14	78.01	0.87
	5	78.27	79.07	0.80
	10	79.73	79.93	0.20
	25	80.15	80.19	0.04
	100	81.58	81.53	-0.05
	Regional	85.57	85.81	0.24
C.N. Railway	2	76.46	76.60	0.14
	5	77.83	78.38	0.55
	10	79.07	79.33	0.26
	25	79.35	79.45	0.10
	100	80.27	80.23	-0.04
	Regional	85.52	82.33	-3.19
Brampton Street	2	75.65	75.60	-0.05
	5	76.66	77.00	0.34
	10	77.38	78.16	0.78
	25	77.53	78.56	1.04
	100	77.93	79.63	1.70
	Regional	79.64	81.97	2.33

TABLE 3 (cont'd)

FLOOD ELEVATION COMPARISONS

LOCATION	RETURN PERIOD DESIGN STORM	WATER LEVELS (MASL) PRE CONSTRUCTION	WATER LEVELS (MASL) POST CONSTRUCTION	INCREASE IN LEVELS (m)
Burlington Street	2	74.94	75.00	0.06
	5	75.62	75.90	0.28
	10	76.15	76.57	0.42
	25	76.28	76.76	0.48
	100	76.54	77.21	0.67
	Regional	77.72	78.02	0.30
Woodward Avenue (Mouth of Creek)	2	74.67	74.66	-0.01
	5	74.63	74.68	0.05
	10	74.82	74.63	-0.19
	25	74.52	74.74	0.22
	100	74.59	75.04	0.45
	Regional	75.92	76.13	0.21

Note: 1) Levels presented are for locations just upstream of each indicated crossing.

2) Levels for post construction condition take into account changes in flows.

- flood levels at the C.N.R. embankment will rise slightly for the 5 Year storm (0.5 m) and will be essentially unchanged for the 2, 10, 25 and 100 Year storms. The Regional flood level will be lowered significantly (3.2 m) due to overflow through the new opening which will be created in the embankment to accommodate the expressway.

- flood levels in the Brampton Street area will remain unchanged for the 2 Year storm. For the other storms analysed however, increases ranging from 0.3 m for the 5 Year to 2.3 m for the Regional storm were predicted. These increases are due partly to increased flows but primarily to the presence of a crossing and embankment for Brampton Street following construction of the expressway, where one doesn't exist at present.

- flood levels at Burlington Street will increase slightly due to increased flows. These increases range from 0.06 m for the 2 Year storm to 0.7 m for the 100 Year storm with an average of 0.37 m.

- flood levels at Woodward Avenue near the mouth of the creek will not be significantly affected. Levels in general will be slightly less for the 2 to 10 year storms and slightly greater for the storms ranging in size from 25 Year to Regional level.

5.0 CONCLUSIONS

Based on the analysis described and results presented herein, it is concluded that:

1. Peak flows resulting from storms ranging in size from 2 year to 100 year will, in general, increase after the construction of the proposed expressway due to losses of effective flood storage. Such increases will vary somewhat depending on location and storm and for most of the area are in the 30% to 50% range.

2. Peak flows from the Regional storm will not increase significantly downstream of Barton Street (13 to 14% range). From the TH+B embankment to Queenston Road, Regional storm peak flow increases will range from 75% to 22% respectively.

3. Post construction flood levels from the mouth of the creek upstream to Barton Street will generally increase slightly for the conditions analysed (with the exception of the Regional storm at the C.N.R.). Levels in this area will only increase significantly in the Brampton Street area where the increase is primarily due to a post construction Brampton Street crossing, rather than the expressway itself.

4. Post construction flood levels from Queenston Road to the end of the affected area (TH+B embankment area) will be in general significantly lower (except for very large storms at King Street).

5. If increased flows can be safely conveyed to the mouth of the creek without creating adverse effects, some increase in peak flows is acceptable.

6.0 RECOMMENDATIONS

During final design of the expressway and its associated structures, it is recommended that:

1. Attention be paid to minimizing the loss of effective flood storage along the valley, particularly in Reaches 709.1 and 711.1 where most of the impact of the expressway was found.

2. Consideration be given to creating compensatory storage in Reach 709.1 and elsewhere to help offset the impact of the expressway. From the topographic mapping of the area, it appears possible that a significant portion of the storage loss in Reach 709.1 could be regained. Minimizing storage loss and optimizing storage use in the final design phase will lead to lower flood peaks in the downstream reaches and thus help reduce the costs of the downstream structures.

3. The final channel and structures be designed to safely convey the design flows to be expected.

All of which is respectfully submitted.

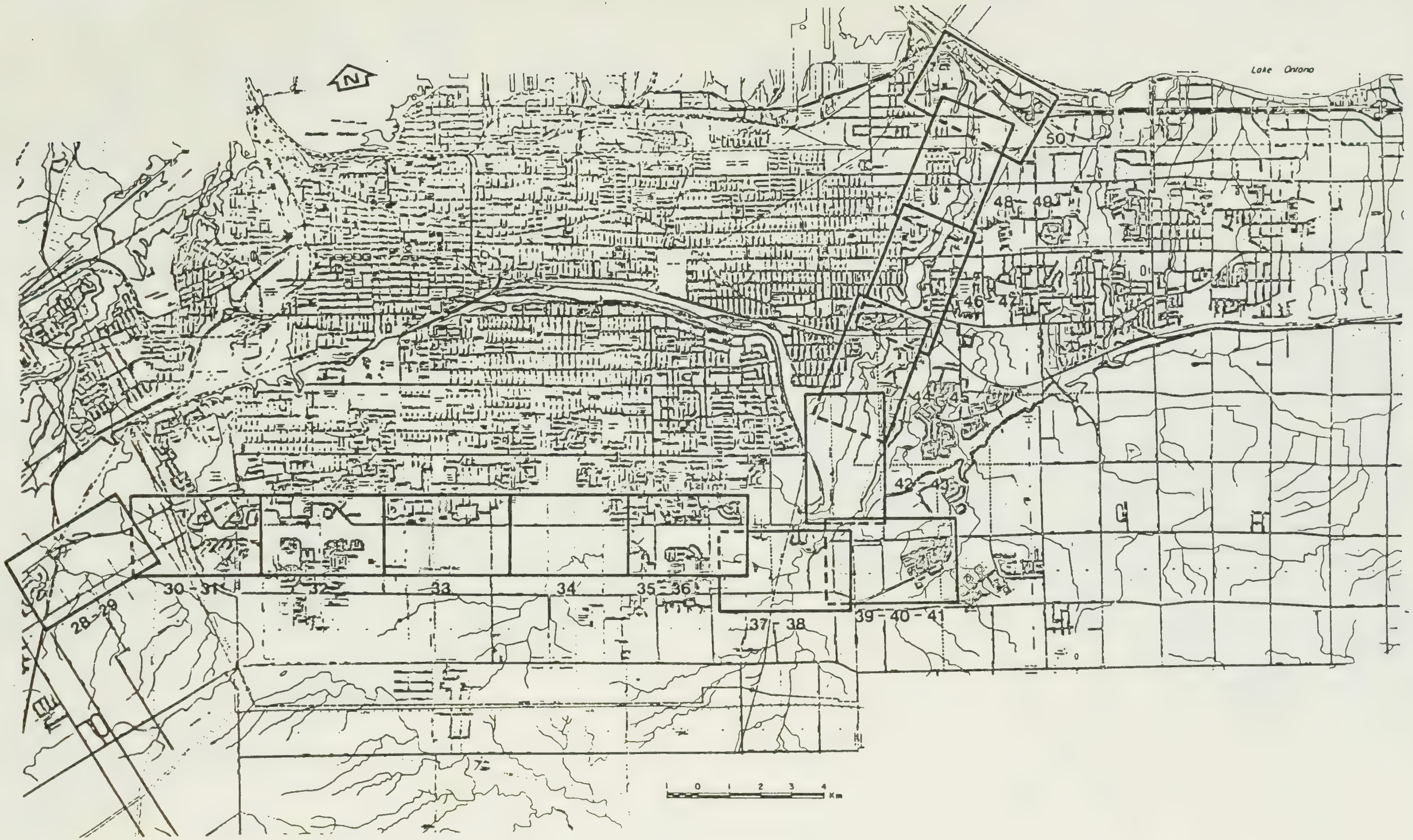
PARAGON ENGINEERING LIMITED

Larry Thompson

Larry Thompson, M.A.Sc., P.Eng.

APPENDIX

LOCATION OF PROPOSED NORTH-SOUTH TRANSPORTATION CORRIDOR



LEGEND

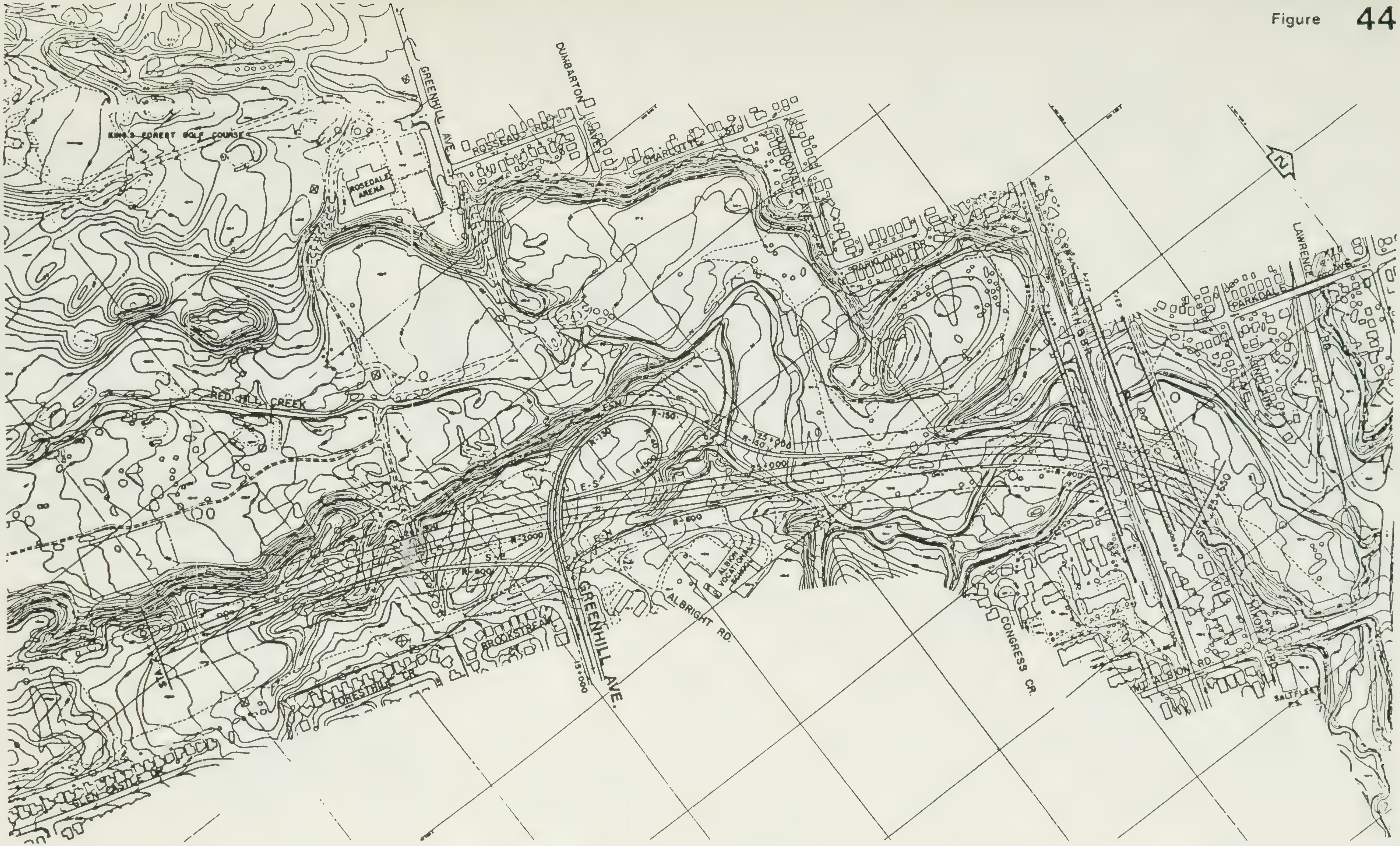
28-29 — PLAN - EXHIBIT NUMBER
28-29 — PROFILE - EXHIBIT NUMBER

MOUNTAIN EAST-WEST and NORTH-SOUTH
CORRIDOR STUDY

PLAN AND PROFILE SHEET INDEX

DeLCan

Figure 44



0 40 80 120 160 200

Scale: 1:5000

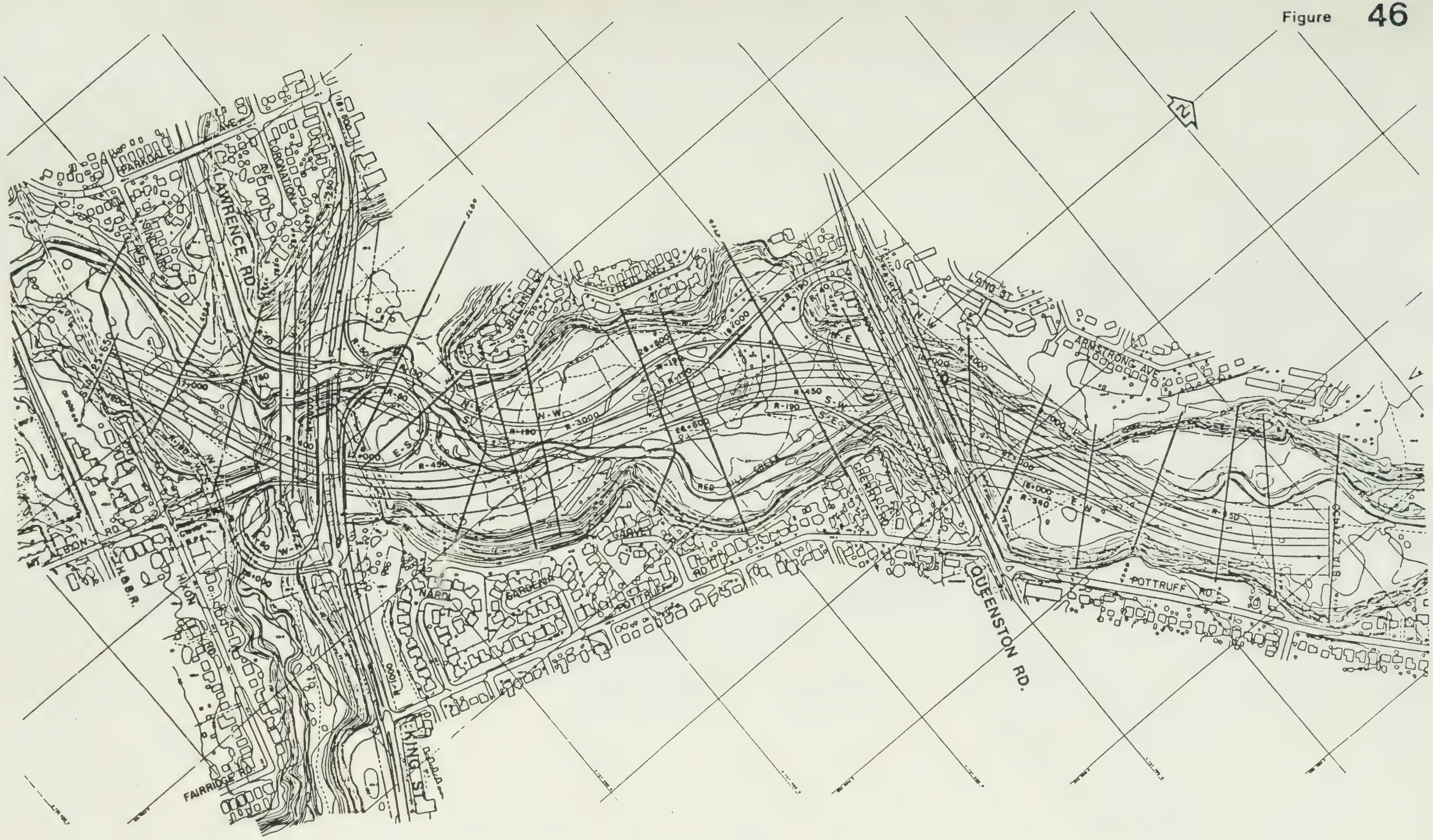
DelCan

MOUNTAIN EAST-WEST and NORTH-SOUTH
CORRIDOR STUDY

NORTH-SOUTH PARKWAY

STA. 24 + 100 To STA. 25 + 650

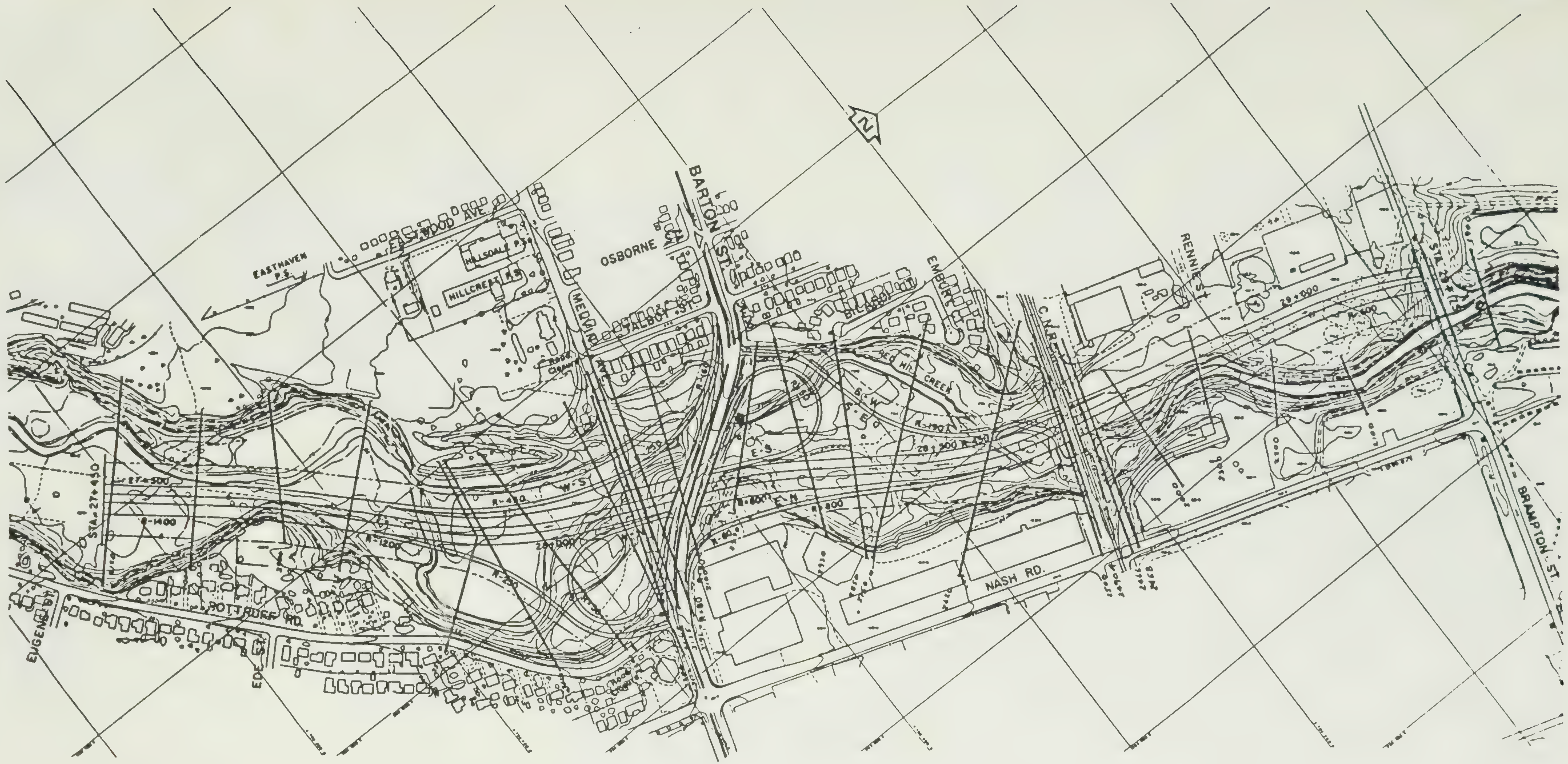
Figure 46



MOUNTAIN EAST-WEST and NORTH-SOUTH
CORRIDOR STUDY

NORTH-SOUTH PARKWAY

STA. 25 + 650 To STA. 27 + 450



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Scale: 1:5000

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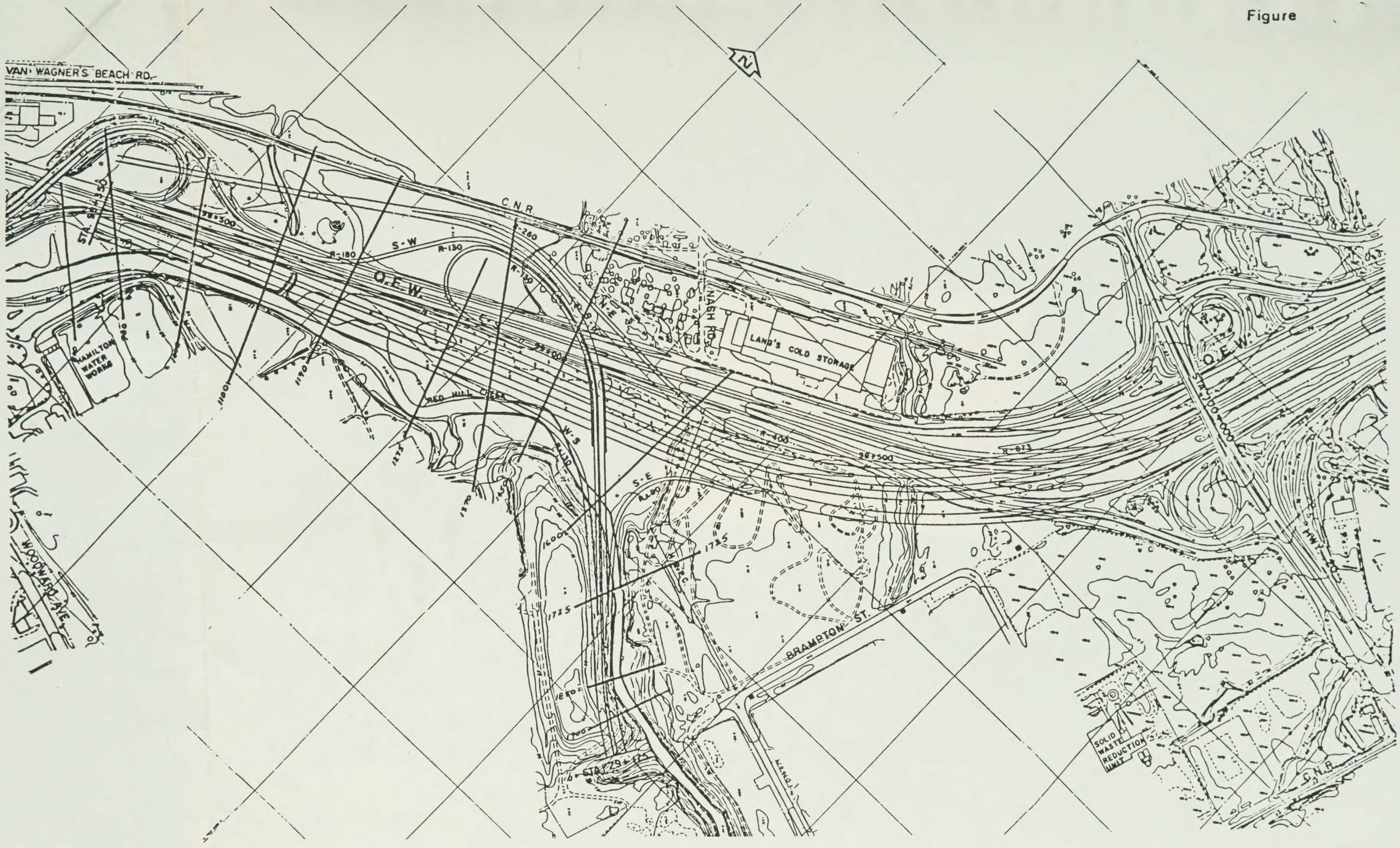
MOUNTAIN EAST-WEST and NORTH-SOUTH
CORRIDOR STUDY

NORTH-SOUTH PARKWAY

STA. 27 + 450 To STA. 29 + 175



0 40 80 120 160 200

Scale: 1:5000

MOUNTAIN EAST-WEST and NORTH-SOUTH
CORRIDOR STUDY

NORTH-SOUTH PARKWAY

STA. 98 + 350 To STA. 100 + 000

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